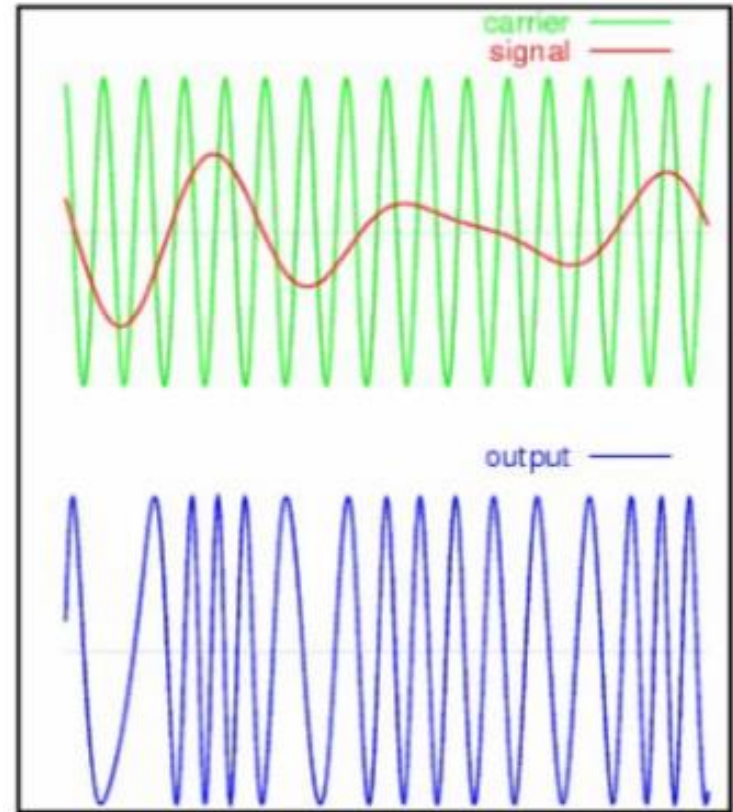


FREQUENCY MODULATION MATLAB SESSION

ECE 328 – PRINCIPLES OF COMMUNICATION

WHAT IS FM MODULATION?

- **Frequency modulation** is a form of modulation, which represents information as variations in the instantaneous frequency of a carrier wave.
- In analog applications, the carrier frequency is varied in direct proportion to changes in the amplitude of an input signal.



FREQUENCY MODULATION / 01

- The FM-modulated signal has its instantaneous frequency that varies linearly with the amplitude of the message signal.
- We can get the FM-modulation by the following:

$$\varphi(t) = \cos(2\pi f_c t + 2\pi k_f \int_0^t m(\tau) d\tau)$$

- where K_f is the sensitivity factor, and represents the frequency deviation rate as a result of message amplitude change.
- The instantaneous frequency is:

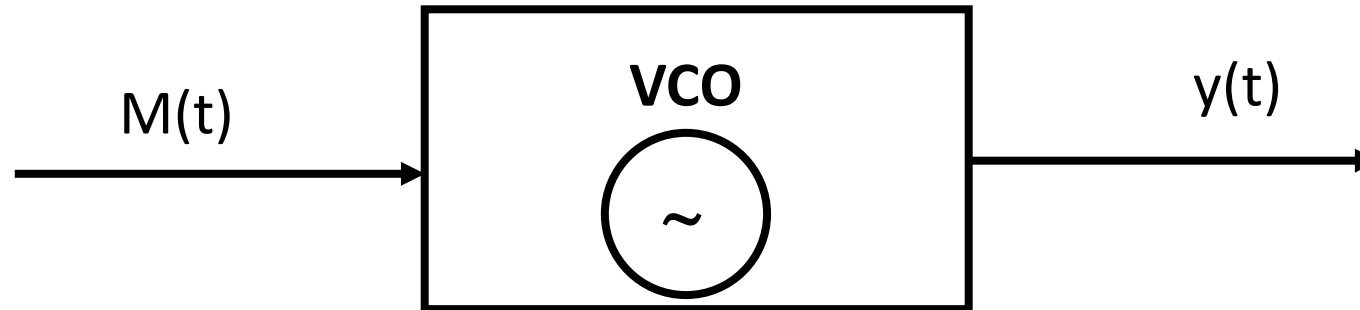
$$\omega_i = 2\pi f_c + 2\pi k_f m(t)$$

FREQUENCY MODULATION / 02

The maximum deviation of f_c or maximum shift away from F_c in one direction is given by

$$\Delta f = k_f m(t)_{\max}$$

The FM-modulation is implemented by controlling the instantaneous frequency of a voltage-controlled oscillator(VCO).

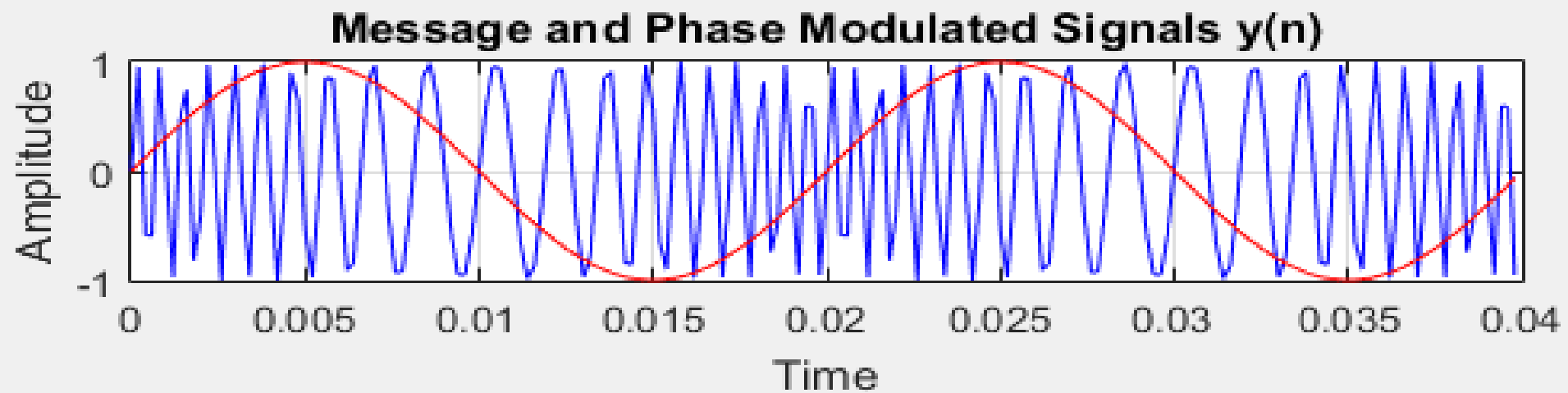
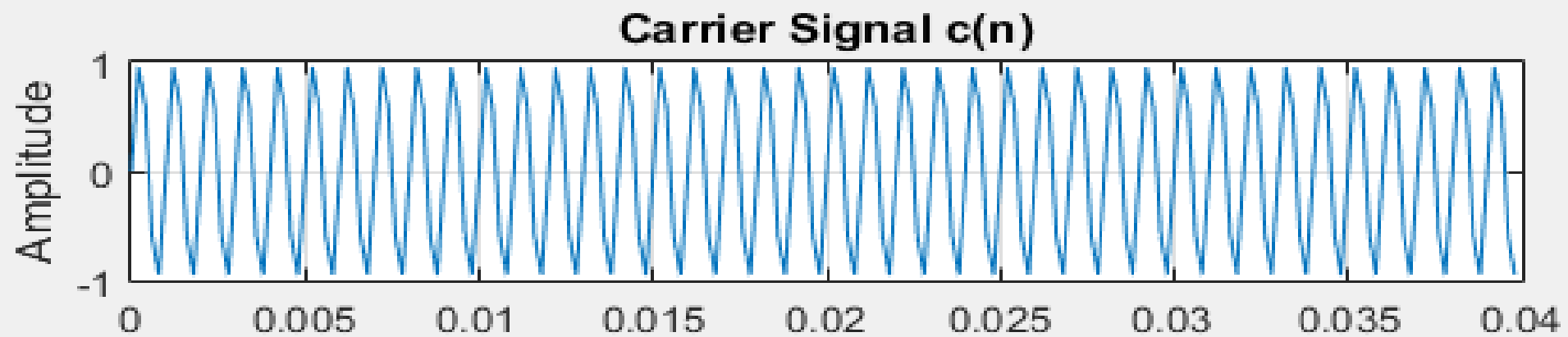
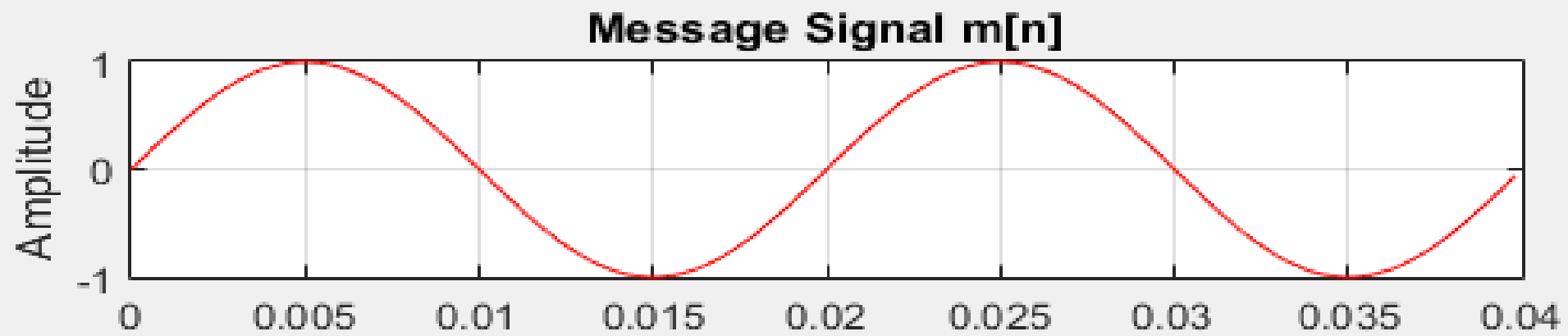


FREQUENCY MODULATION / 01

```
fs = 5000;
t = 0:1/fs:1-1/fs;
m = sin(2*pi*50*t);           % modulating signal
subplot(3,1,1);
idx = 200;
plot( t(1:idx), m(1:idx), 'r' );
grid
ylabel('Amplitude')
title('Message Signal m[n]')
fc = 1000;                     % Carrier frequency
c=sin(2*pi*fc*t);              % carrier signal
mi = 10; % modulation index
```

FREQUENCY MODULATION / 02

```
y=sin(2*pi*fc*t+(mi.*m));    % Phase Modulation
subplot(3,1,2);
plot(t(1:idx), c(1:idx));
ylabel('Amplitude');
title('Carrier Signal c(n)')
grid
subplot(3,1,3);
plot( t(1:idx), y(1:idx),'b', t(1:idx), m(1:idx), 'r' );
grid;
xlabel('Time')
ylabel('Amplitude')
title('Message and Phase Modulated Signals y(n)')
```



SPECTRUM OF FM SIGNAL

Append the following:

```
N=5000;  
k=1:N/2;  
F=fft(y);  
M=fft(m);  
magF=abs([F(1)/N, F(2:N/2)/(N/2)]);  
magM=abs([M(1)/N, M(2:N/2)/(N/2)]);  
figure  
plot(k, magF, 'b' , k, magM, 'r');  
title('Spectrum')
```

